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Testing and Training in a Command, Communications, Control, and Intelligence (C3I) Framework

In a theater of operations, the C3I system is the nervous system of the force. It is the collection of pipes, wires, and channels through which information about enemy activity, status of forces, directions, and orders flow. At the component level, C3I systems are Service specific, and tailored to meet Service needs. At the theater level, C3I systems are tailored to meet theater specific needs, and the architecture varies from unified command to unified command. The theater level C3I system must integrate the component level systems into a seamless apparatus which will support theater-wide operations.

At any given point in time, the military forces of the US are dispersed around the globe. Unit training is going on overseas, in the theaters, and in the CONUS. Where units are involved, C3I is a player. To some degree, the CONUS training has to be generic. CONUS based forces may have to deploy in support of more than one theater, so training can't be specific to a single theater. To complicate matters further, within the areas of responsibility of the Commanders in Chiefs (CINCs), the C3I system has to be modified to adapt to different geographic regions so that allied and friendly regional capabilities can be integrated into the system.

One consequence of the complexities of individual C3I applications is a certain "settling" time at the outset of large-scale operations. My perceptions may be somewhat dated, but in my own experience, the first few days of large-scale exercise or combat activities suffer from significant levels of C3I related confusion. It takes time for the participants to figure out which button to push, and which rope to pull. It takes time for the technicians to set up equipment, and figure out why it doesn't work the way it's supposed to. It takes experience to figure out that procedures and policies which looked good on paper have to be modified in the face of actual operations.

One function of large-scale field exercises has been to provide C3I training. It is arguable that even when money wasn't critically short, there weren't enough exercises to avoid, or even significantly reduce, the confusion mentioned earlier. It is clear that the number and scope of large-scale field exercises will be reduced, perhaps drastically reduced, in the current and future fiscal environment.

Command Post Exercises (CPXs) are designed specifically to provide C3I related training. CPXs are significantly less costly than large-scale deployments and exercises, but they have a number of shortcomings. In CPXs, relatively little actual field activity takes place. The problems experienced in the siting, set-up, calibration, tear-down, and relocation of equipment don't show up. The confusion associated with large-scale field activity is present, but much more subdued. The scope of the C3I architecture may be

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greatly reduced from actual theater level architectures. While CPXs provide some valuable training, they clearly offer less than large-scale field exercises, and they simply do not approach the complexities of the real world.

C3I systems, by their very nature, are complex, and at the higher levels they are designed to support a multiplicity of interfaces. The underlying technology which supports C3I is Information Systems Technology (IST). IST is an area where advances are occurring with incredible speed. System capacities and speeds have been increasing exponentially, and that pattern is continuing. As the Services adapt to, and take advantage of, newer technologies, hardware and software changes are introduced. New stuff --- hardware, or software --- requires exploration, and much of that exploration is (or should be) conducted in formal testing programs.

Since C3I systems are complex, the introduction of new things can have a cascading effect which reverberates to and through interfaces to other elements of the system. Unanticipated complications can arise when a new piece of equipment is introduced into a C3I system. Typically, the assessment and testing activities associated with that new equipment begin in a local fashion. Only after the changes are absorbed locally does the testing perspective broaden to external interfaces. The opportunities for testing in the broad perspective are very limited. That's dangerous. The Joint Advanced Distributed Simulation (JADS) Joint Test and Evaluation (JT&E) program experience clearly demonstrates that testing below the full-up level doesn't get the job done. On the other hand, dedicated high level testing plainly and simply is infeasible. Testing either is limited to a severely scoped down C3I environment, or it has to be shoe-horned into training exercises.

Operators are concerned about training. They tend to be suspicious of, if not downright hostile to, testers. The operators' concern is real. They fear that the extremely limited large-scale training opportunities will be diminished when training objectives are impacted by testing requirements. On the other hand, the operators concern should be balanced by a recognition that we don't train solely for the sake of training --- we train to carry out actual military operations. If new items of equipment are going to be fielded in support of actual operations, then it behooves the operators to see that that equipment works well, and is fully understood.

Despite the complexities of C3I systems, there are some serendipitous factors at work. C3I architectures are networks or collections of networks. The networks may employ digital or analogue formats, and they may use wires, fiber optic lines, microwave, RF, laser, or other media. Advanced Distributed Simulation (ADS) is also about networks. ADS is about linking nodes, and C3I is about linking nodes. ADS is fully capable of using all of the formats and media employed in C3I systems, and it offers some opportunities to approach C3I training in new ways.

In the recent past, the Department of Defense (DoD) has gained some experience in large netted environments. Synthetic Theater of War-Europe (STOW-E) comes to mind immediately, and I'm sure there have been other examples as well; some netting aspects

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were applied in the last Roving Sands exercise. That experience base can serve as a springboard for some innovative approaches to training, testing, and preparation for operations.

The "S" in "ADS" can be misleading in some circumstances. Some people interpret it to mean that ADS is used to link simulations. In fact, an ADS architecture could link all "real" players. In such a case, the "simulation" is the shared virtual environment created by the interactions among and between the "real" players. ADS can, of course, link simulations, or mixes of real and simulated players. In the lexicon of distributed simulation, ADS can link, in any combination, live, virtual, and constructive entities.

The attributes of ADS would support the replication of any C3I system, to include human operators and decision makers at any chosen node. Both the people and the hardware immersed in the architecture would react to a common underlying operational environment. Individual links within the architecture could also be "real" or "simulated". As an example, if a real world link is line of sight, and the participants in an ADS exercise are beyond line of sight, then the link must be simulated by a reconstructed architecture. The inputs and outputs of the link, however, could be "real", and timing differences are generally minimal. The simulated link could look normal to the users.

If an ADS replication for a C3I system is constrained to the use of real systems in garrison and existing simulations, then the major expense of the exercise is associated with networking and instrumentation costs. Networking costs include the fees for lines and channels, and the investment in software development to support translation and transformation functions. Instrumentation costs are test driven, and case specific. Aside from the manpower devoted to operating and maintaining the ADS architecture, participants are doing what they are paid to do --- e.g., either training or testing.

If, for heightened realism, forces and C3I elements are deployed to the field, then that is an additional expense. That expense, however, is only slightly increased by ADS peculiar costs. In return for investment, ADS can bring richness to the C3I environment. Expensive command and control warfare assets such as an Airborne Command and Control Center (ABCCC), an Airborne Warning and Control System(AWACS), or an Airborne Laser (ABL) can be brought to the exercise at cost-effective levels of fidelity. If accuracy demands a real player, it can be accommodated in the structure. If a high fidelity manned simulation or a model is sufficient, they too can be accommodated, and at significant savings compared with a live player.

In today's geopolitical environment, the military never knows with certainty whether it will be called upon to destroy an enemy, or feed a population in distress. A C3I system which supports large-scale combat operations probably doesn't look much like a system required to support humanitarian operations. There's a possibility that unique C3I systems will have to be tailored on short notice for a variety of purposes. Assuming some warning interval, ADS affords a wonderful opportunity to prepare for an operation of any type.

In cases where a CONUS deployment will be integrated with theater forces, the integration of C3I assets can begin prior to actual deployment. Hardware, software, and people can be interfaced in an ADS architecture. Long-haul links in a Wide Area Network (WAN) can be used as substitutes for what will become short-haul links in a Local Area Network (LAN), and the network can be used to support rehearsal of C3I activities. Actual equipment can be used wherever required, and procedures can be assessed and fine tuned. If new equipment is available, it can be tested during rehearsal rather than on-scene after deployment. (Rehearsal can be considered as a specialized form of training.) The investment in a rehearsal system should return dividends during actual operations.

In cases where a CONUS deployment will provide the only forces, a mock up of the post-deployment C3I structure can be created at home station locations. In this case, short-haul LAN links substitute for long-haul WAN links, but once again, actual hardware, software, and human participants can be used. New items of equipment can be rigorously tested in the CONUS environment before they are shipped to the deployed locations.

C3I systems in the general case support decision-making, and decision-making, at least at the higher levels, remains a human function. Human beings are relatively insensitive to delays in the millisecond regime, so the time delays (latency) associated with ADS are usually tolerable. From an architectural point of view, each link probably has its own set of requirements, and almost certainly there will be some aspects of an ADS architecture which have shortcomings in timing, fidelity, or both. On the whole however, ADS has the potential to provide an affordable training, rehearsal, and testing tool for a wide variety of environments and missions.

The past use of ADS in the training environment has had strong emphasis on visual representation. There are many training applications where it is important that the participants see, with their eyes and sensors, the same battlespace. In the C3I world, there may still be requirements for visual stimulation, but more often than not, the visual stimulation will be provided through some sort of computer driven display. ADS supports the use of actual equipment, including displays. In the high level C3I world, it is important that all of the participants are responding to a common theater-level operating environment, but few if any participants actually "see" that total environment. Instead, various players deal with some subset of the environment --- the field of view of a sensor, human reports on local enemy activity, unit status reports, etc. What is important is consistency between the subsets each participant deals with, and the theater level set. In a properly constituted ADS environment, that consistency derives from the interactions of the participants. Their interactions create a data base which supports, moment by moment, the representation of the theater. That common data base, in turn, stimulates each participant to "do his own thing".

The JADS Joint Test Force is conducting several tests, but one in particular, the End-to-End test (ETE) has some relevance to this topic. The ETE test is focused on exploring the utility of ADS for evaluation of Command, Control, Communication, Computer,

Surveillance, and Reconnaissance (C4ISR) systems. The vehicle for testing ADS utility is the Joint Surveillance Target Attack Radar System (Joint STARS).

Joint STARS is a sensor which sees a very large chunk of the theater battlespace. What Joint STARS sees is downlinked to Joint, Army, and Air Force command and control centers, and the information is used to support estimates of the situation, targeting, maneuver, and force disposition decisions. The Joint STARS system includes the E-8C aircraft, and the collection of ground stations which receive the downlinked data from the aircraft. There is a separate presentation at this symposium on the ETE, so I won't delve into specifics on the test, but what's of interest to this topic is the ADS implementation.

Behind the Joint STARS radar, everything in the system is processors and displays. As long as the operators at the displays see what they expect to see in terms of image characteristics and quality, and target behavior, they can't tell if the data is coming from live or virtual sources. The ETE test has made the investments to provide seamless representation of real stuff, virtual stuff, or a mixture of the two. The operators are receiving realistic training, and the decision makers are receiving the information they need to do their jobs. When attacks are carried out, the effects are captured in the ADS architecture, the theater data base is modified to reflect results (in near-real-time), and Joint STARS sees the resulting changes in target behavior, and the cyclically modified picture is downlinked to the ground stations. (The End-to-End name was derived from the fact that the complete cycle from target detection, to attack, to results, was represented in the ADS implementation.) Every player in the architecture responds to the same data base, so a Remotely Piloted Vehicle(RPV) entity doing a local scan would see, in microcosm, the same picture that Joint STARS, and the command centers it feeds, see.

The ETE ADS architecture works well because of the prevalence of display interfaces and the fact that the cycle time on the radar is insensitive to the magnitudes of latency experienced in the system. The human windows on the battlespace are the displays, and the displays look just like they ought to. Throughout the C3I structure, information is presented graphically, and with rare exception, there is no need for visual rendering of vehicles, structures, and the like. (The information on terrain and structural features is in the data base for those players who need it --- it does support Joint STARS Synthetic Aperture Radar [SAR] imaging.) Because the data base is common to all players, there is consistency in the views presented to each player, at every level.

Historically, testing, particularly operational testing, of C3I systems has been a problem. The military worth of a C3I system lies in its ability to support the conduct of the mission --- not in bit error rate (BER), throughputs, etc. Measuring BER, dropout rates, bandwidth, and mechanical reliability is relatively easy to do, so the temptation is to test at that level. The contribution of the Joint STARS is associated with the value of having a better picture of the enemy's force dispositions and intentions, and supporting the attack of time sensitive or fleeting targets. As long as the Joint STARS contribution is worthwhile, system measures like BER fall into the Rhett Butler category --- "Frankly

my dear, I don't give a damn!" There's at least a chance that ADS can improve the quality of training and support more meaningful operational testing.

Given that ADS affords some opportunities for C3I related training, rehearsal, and testing, what are the drawbacks? One of the most obvious, from the operator's perspective, is a need to test systems which have not been fielded yet. The operators are reluctant to have the shape of an exercise significantly altered by the presence of an "artificial" capability. The testers are reluctant to have the behavior of their "new" system buried in the heaps of data emanating from a large exercise.

I believe that some careful planning can minimize the impact of training on an exercise and maximize the data return to testers. It has to be joint (small "j") planning; both the trainers and the testers have to work together from the outset.

C3I systems don't kill or destroy things. They support the ability to kill and destroy, but in and of themselves, they simply provide information. Because of that, it should be possible to segregate new items of C3I equipment and software within an exercise architecture. There could be a "new equipment cell" which has access to the common exercise data base, and which "sees" the battlespace through its own sensor suites. The data peculiar to the new capability does not have to be injected into the exercise C3I system --- it can be retained within the "new equipment cell" where comparisons such as system data and ground truth could be made. Such an approach would give the testers some relatively clean data sets.

In some cases, a Commander in Chief (CINC) may want an emerging system actively included, as opposed to segregated, in his exercise C3I architecture to support assessments and product improvement recommendations. That approach probably sheds light on the potential military worth of the system which should be of interest to the testers. In any case, as long as the exercise planners and the system developers and testers have a free exchange of ideas, some reasonable accommodations can be made.

I believe the operators would benefit from a closer relationship with the testers where new equipment and capabilities are involved. The potential set of operational benefits could include the ability to influence system design, refinement of concepts of operations and procedures to maximize system contribution, and a better understanding of existing C3I system behavior. The testers would benefit from the closer relationship by gaining a better understanding of how the operator does business, and the set of really important performance parameters.

There are some infrastructure needs implicit in the ability to effectively use ADS in ways I have discussed. Infrastructure, of course, costs money and resources. For the operators, there is a requirement to have the technical skills, and the specialized equipment to establish, monitor, and control distributed systems. Some of that probably already exists, but almost certainly, some of it does not. Testers need the technical skills and specialized equipment as well, but they also need the analytical and engineering skills to understand the characteristics of distributed systems. That understanding has to

cover the sources and types of errors associated with distribution, the kinds of instrumentation required to support testing, design approaches which minimize errors, etc.

There may also be another level of infrastructure costs where there is an effort to standardize interfaces so that linking becomes an easier exercise. The current approach, as embodied in the High Level Architecture (HLA), is to manage interfacing at a software, as opposed to a hardware level. If that works as intended, cost should be tolerable.

In summary, advances in IST offer some opportunities for revisiting the way we train to use C3I systems, and the way we test C3I systems. There are costs associated with ADS capabilities, but the issue for us should be cost effectiveness, not absolute costs. If we think really hard, we can probably come up with some high-payoff, innovative approaches to setting up and checking out C3I architectures. Those approaches could support both improved training, and improved testing. Perhaps most importantly, approaches to rehearsal of C3I processes and procedures could reduce the confusion which comes with initial operations in a strange environment. In combat operations, initial confusion can cost lives and lose objectives. Some preparation investment can reap large rewards in actual operations.

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